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The Effect of Profile of Backing Plate Upon the Fatigue Life of a Cantilever Discharge Valve Reed

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ABSTRACT

The paper presents a case study of the effect of profile of backing plate upon the fatigue life of a cantilever type discharge valve reed used in a small air conditioning rotary compressor. Two kinds of backing plate were considered. Numerical analyses on bending stresses of valve reed with two different kinds of backing plate respectively has been performed using the commercial finite element program ANSYS.

INTRODUCTION

In recent years, the developments in compressor technology have been directed towards higher efficiency and reliability, both for refrigerating and air conditioning compressors. The most important factor in improving compressor reliability is the reduction of the probability of failure of the compressor valve reeds where the highest stress occur. Examination showed that most of valve failures were caused by bending fatigue and/or impact fatigue. During the past,extensive case studies of valve failure have been performed and presented. Considerable amount of published work exists in the area of valve design. Valves can fail not only due to material , design or manufacturing defects of valve reeds themselves but also due to overloading, improper assembly, and environmental effects. Therefore, special attention must be given to the influence of seat position, seat shape and the shape of backing plate on valve fatigue performance[1-4].

The paper presents a case study of effect of profile of backing plate upon the fatigue life of a cantilever discharge valve reed used in a small (2000 kcal/hr) air conditioning rotary compressor. The compressor valve system includes discharge valve reed, seat and backing plate as shown in figure 1. Two kinds of backing plate were considered. There is only minor difference between their profiles shown in figure 2. However, one showed good valve fatigue life, the other plate with defective profile due to manufacturing carelessness resulted in valve fatigue fracture during actual compressor operationas shown in figure 3. The object of this research is to study the effect of defective profile of backing plate (B) upon the fatigue life of the valve reed and to reduce the probability of fracture of the valve reed by improving the profile of backing plate (B).

ANALYSIS

Figure 2 shows that there are two main differences between profiles of backing plate (A) and (B). Firstly, the length of horizontal part of the profile of backing plate (B) is shorter. Secondly, the curvature of curvy part of the profile backing plate (B) is larger. These differences resulted in changes of boundary conditions and loads on the valve. We analyzed the effect of profile's differences of backing plate upon the fatigue life of valve reed using experimental method and finite element method.

Natural Frequencies Measurement:

The instrumental arrangement of natural frequencies measurement of valve reed is shown in figure 4. Two kinds of backing plate were bolted respectively on the frame with valve reed. We found that the natural frequencies of vale reed with backing plate (A) and (B) are 388 Hz and 297 Hz, respectively, from the vibration spectra shown in figure 5. Since the length of horizontal part of the profile of backing plate (B) is shorter, the length of valve reed cramped by the plate and frame is shorter. The natural frequency of valve reed is reduced to 297 Hz which is about five times as that of the compressor's (59.2 Hz), which may cause resonance problem and reduction of fatigue life of the valve reed.

Bending Stresses Analysis of valve reed using ANSYS:

Figure 6 shows the finite element model of the discharge valve reed using ANSYS. Natural frequencies analysis of valve reed using ANSYS was performed firstly to compare with experimental results to determine the boundary conditions. The natural frequencies of valve reed performed by ANSYS program for the boundary conditions as shown in Table 1 were closed to the experimental results.

Since the actual pressure loads on the valve reed are unknown, several load steps with increasing magnitude were applied until the valve tip just touched the backing plate. For input in the program, the displacement of the valve tip, Node t as shown in figure 6, was specified to a maximum of 3.3 mm. In addition, the displacement of Node h was specified to 1.0 mm for using backing plate (B) case from the experimental observation and its profile.

THe finite element solutions giving the nodal displacements and maximum principle stresses of the valve reed were obtained. Figure 7 shows Uz displacement plots of nodes along the center line $\overline{st}$. The magnitude and location of maximum principle bending stresses on the valve reed with backing plate (A) and (B) are shown in Figure 8 and 9, respectively. The maximum principle bending stress of the latter is 26% higher than that of the former. Furthermore, the location of maximum principle bending stress of valve reed with backing plate (B) is in consistent with the location of valve fracture during actual operating condition. The results shows that the large curvature of backing plate (B) resulted in higher possibility of failure of the valve reed where the highest stresses occur.

CONCLUSION

The operation life of the compressor valve system was improved and prolonged after the profile of backing plate (B) was repaired. The study demonstrated that small defect on the profile of backing plate due to manufacturing carelessness may result in valve fracture. Therefore, special attention must be given to examine the accuracy of profile of backing plate.

REFERENCES

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3. S. Papasteriou, J. Brown and J.F.T. Maclaren, "Impact Velocities of Valve Reeds", Proceeding of the 1982 Purdue Compressor Technology Conference, pp.249-256.

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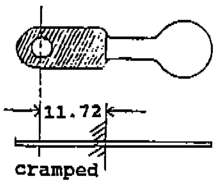
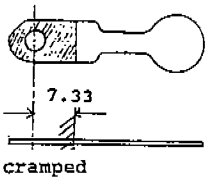
Table 1. Natural Frequencies of valve reed

METHOD / CASE	EXPERIMENTAL METHOD	FINITE ELEMENT METHOD	
WITH BACKING PLATE (A)	388 Hz		380 Hz
WITH BACKING PLATE (B)	297 Hz		307 Hz

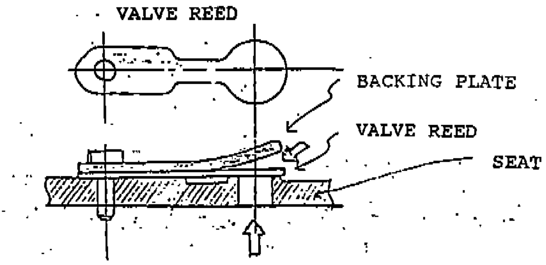


Figure 1. Compressor discharge valve system

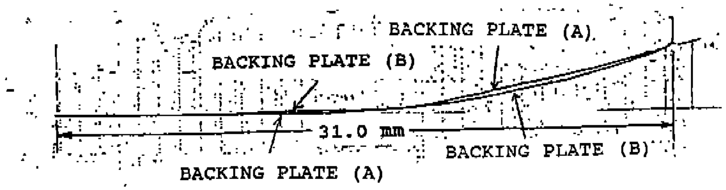


Figure 2. Comparison of profiles of backing plate (A) and (B)

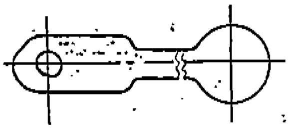


Figure 3. Valve fracture

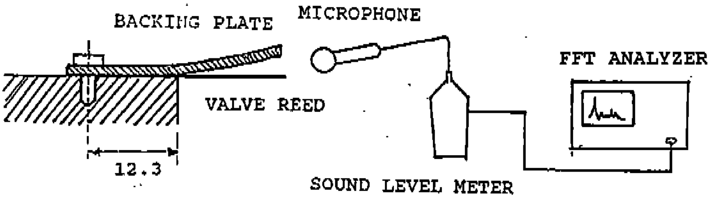


Figure 4. Natural frequencies measurement of valve reed

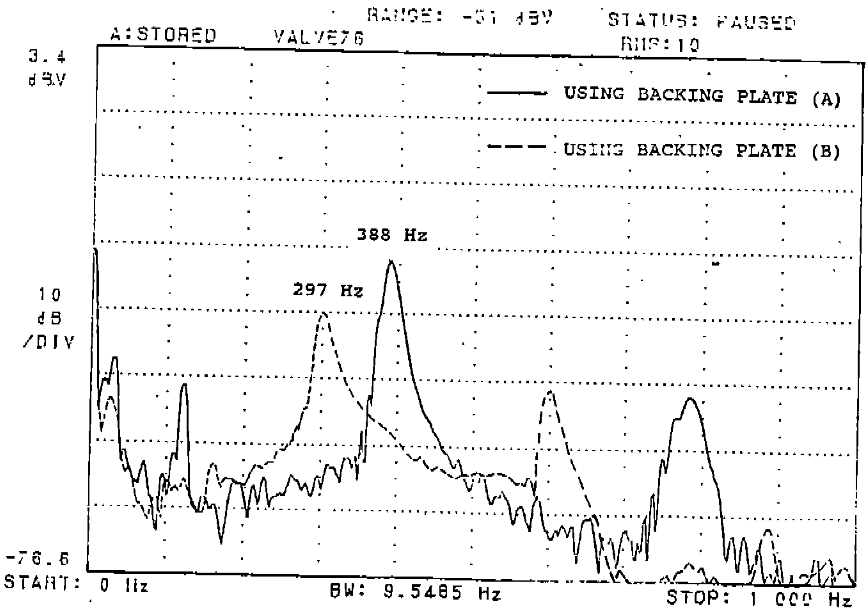


Figure 5. Vibration spectra of valve

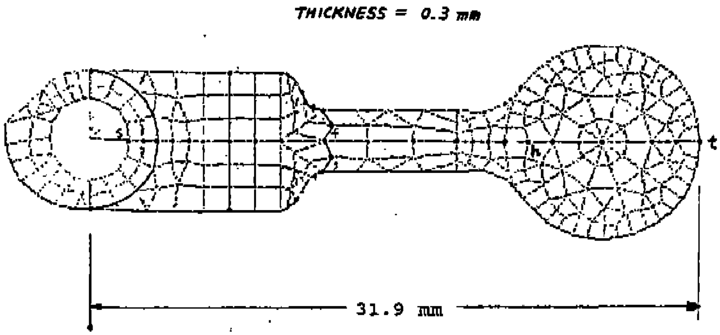


Figure 6. Finite element model of valve using ANSYS

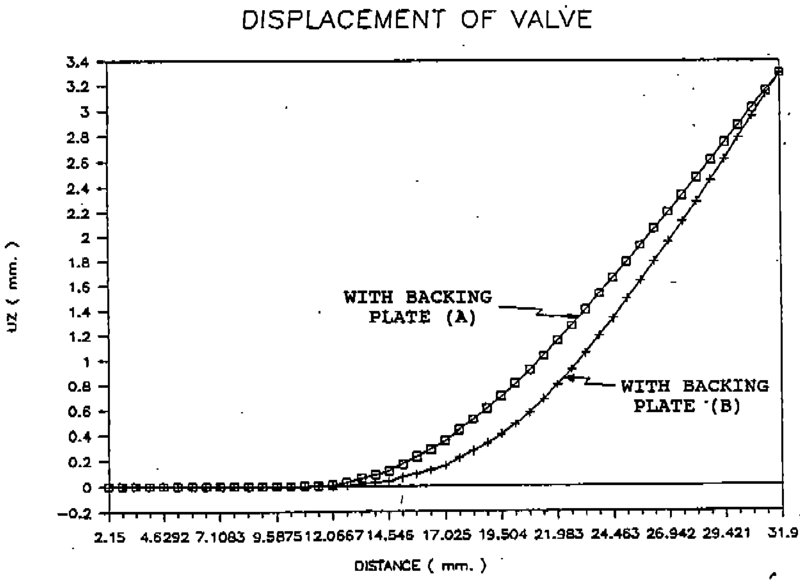


Figure 7. Displacement of valve

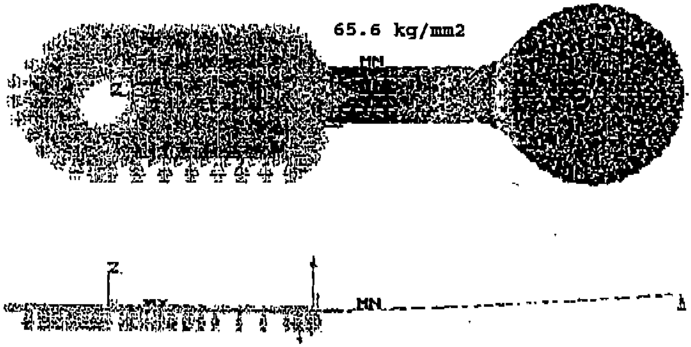


Figure 8. Bending stress distributin of valve with backing plate (A)

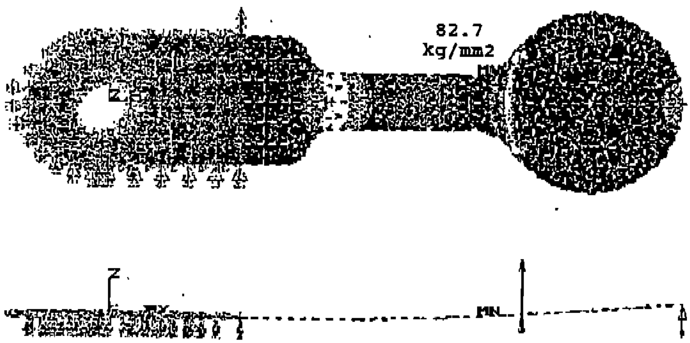


Figure 9. Bending stress distributin of valve with backing plate (B)